THEREFORE WHAT IS CLAIMED IS:

1. A spread space spectrum multiple access method for a forward link in a wireless multi-antenna system serving multiple users, the method comprising the steps of:

multiplexing signals from different users at a base station transmitter having multiple antenna elements, modulating different users' signal streams that are of different/same data rate using a set of multi-rate/equal-rate space-time diagonal (STD) spreading sequences, each user being assigned a unique STD sequence, which modulates one code/information symbol over the spreading period, said STD sequences spanning across the spreading period over different transmitting antennas; and

transmitting the multiplexed signals through the multiple antenna elements at the base station wherein signals from the different users are transmitted simultaneously, a signal from each user being transmitted as a sequence of channel code symbols, where each such symbol is a sequence of direct sequence spread spectrum chips, the sequence of chips (block of chips) is sub-divided into a set of sub-blocks, where each sub-block is transmitted sequentially over a different antenna.

2. The method according to claim 1 wherein each STD sequence is represented by a matrix, where each column has one non-zero value, and wherein elements along a given row represent the chips transmitted on the antenna corresponding to that row.

3. The method according to claim 2 wherein each STD sequence is constructed by

i) defining N, G to be the number of transmitting antennas and the processing gain (or spreading factor) for the lowest rate user, respectively, each STD sequence being represented by a $N \times G$ matrix in which the rows and

columns represent the antenna (space) domain and the time domain, respectively,

ii) defining a set of N broadened space-time diagonals over the space-time grid,

iii) for equal-rate transmission, construct a G by G orthogonal sequences matrix, or, for multi-rate transmission, construct a G by G tree-structured sequences matrix, comprised of orthogonal sequences with different lengths, and

iv) distribute chips of the orthogonal sequences constructed in step iii) along a broadened space-time diagonal, the distribution allowing each sequence to have access to all transmitting antennas (occur at different time instants over the spreading period), repeat for all N diagonals obtained in step ii).

4. The method according to claim 3 wherein the signals from different users are allocated different power levels, according to a quality of service (QoS) requirements including an error-rate performance, associated with different users.

5. The method according to claim 1 including a set of user-specific interleavers, each interleaver performing permutation over a block of code symbols that are delivered by the corresponding user's encoder, wherein each interleaver is uniquely, and randomly chosen from the permutation $\{1,2, \ldots ,n_i\}$, where n_i is the block-length of the i^{th} user's codeword, upon selection of a set of permutations, they are fixed and used in the system over a designated period of time, and wherein after this period of time elapses, another set of distinct random permutations are chosen for the next period.

6. A forward link apparatus in a wireless multi-antenna system serving multiple users, comprising:

a base station transmitter with receivers at users' terminals including multiple antenna elements;

multiplexer means for multiplexing signals from different users are combined and transmitted through the multiple antenna elements at the base station,

processing means for producing a set of multi-rate/equal-rate space-time diagonal (STD) spreading sequences for modulating different users' signal streams that are of different/same data rate, each user being assigned a unique STD sequence, which modulates one code/information symbol over the spreading period, said STD sequences spanning across the spreading period over different transmitting antennas; and

wherein signals from the different users are transmitted simultaneously, a signal from each user is transmitted as a sequence of channel code symbols, where each such symbol is a sequence of direct sequence spread spectrum chips, the sequence of chips (block of chips) is sub-divided into a set of sub-blocks, where each sub-block is transmitted sequentially over a different antenna.

7. The apparatus according to claim 6 wherein each STD sequence is represented by a matrix, where each column has one non-zero value, and wherein elements along a given row represent the chips transmitted on the antenna corresponding to that row.

8. The apparatus according to claim 7 wherein each STD sequence is constructed by

i) defining N, G to be the number of transmitting antennas and the processing gain (or spreading factor) for the lowest rate user, respectively, each STD sequence being represented by a $N \times G$ matrix in which the rows and

columns represent the antenna (space) domain and the time domain, respectively,

ii) defining a set of N broadened space-time diagonals over the space-time grid,

iii) for equal-rate transmission, construct a G by G orthogonal sequences matrix, or, for multi-rate transmission, construct a G by G tree-structured sequences matrix, comprised of orthogonal sequences with different lengths, and

iv) distribute chips of the orthogonal sequences constructed in step iii) along a broadened space-time diagonal, the distribution allowing each sequence to have access to all transmitting antennas (occur at different time instants over the spreading period), repeat for all N diagonals obtained in step ii).

9. The apparatus according to claim 8 wherein the signals from different users are allocated different power levels, according to a quality of service (QoS) requirements including an error-rate performance, associated with different users.

10. The apparatus according to claim 6 including a set of user-specific interleavers, each interleaver performing permutation over a block of code symbols that are delivered by the corresponding user's encoder, wherein each interleaver is uniquely, and randomly chosen from the permutation $\{1,2, \ldots ,n_i\}$, where n_i is the block-length of the i^{th} user's codeword, upon selection of a set of permutations, they are fixed and used in the system over a designated period of time, and wherein after this period of time elapses, another set of distinct random permutations are chosen for the next period.

11. The method according to claim 6 including global power optimization including

defining $P = [P_{\alpha,1,1}\ P_{\alpha,1,2} \cdots P_{\alpha,2,K_1}\ P_{\alpha,2,1}\ P_{\alpha,2,K_2} \cdots P_{\alpha,B,K_B}]^T$ and **Z** is the link gain matrix, which can be expressed as a block-matrix,

$$\mathbf{Z} = \begin{bmatrix} \mathbf{Z}^{(11)} & \mathbf{Z}^{(12)} & \cdots & \mathbf{Z}^{(1B)} \\ \mathbf{Z}^{(21)} & \mathbf{Z}^{(22)} & \cdots & \mathbf{Z}^{(2B)} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{Z}^{(B1)} & \mathbf{Z}^{(B2)} & \cdots & \mathbf{Z}^{(BB)} \end{bmatrix}$$

where the entries of $\mathbf{Z}^{(mn)}$ are given by,

$$\mathbf{Z}^{(mn)}_{ij} = \begin{cases} \dfrac{G_{n,(m,i)}}{G_{m,(m,i)}} & \text{if } m \neq n \\ 1 & \text{if } m = n,\ i = j \\ 0 & \text{if } m = n, i \neq j \end{cases}$$

solving for minimum real λ such that an inequality holds,

$$\lambda \mathbf{P} \geq \mathbf{Z}\mathbf{P}$$

which has solutions for **P** **0** is λ=λ*

and an achievable SINR level (γ*) is given by,

$$\gamma^* = \max\{\gamma \mid \exists \mathbf{P} \geq \mathbf{0} : \Gamma_{m,i} \geq \gamma, \forall i\} = \frac{1}{k(\lambda^* - 1)}$$

12. The apparatus according to claim 6 including set of user-specific interleavers, wherein each interleaver is to perform permutation over a block of code symbols that are delivered by the corresponding user's encoder, each interleaver being uniquely, and randomly chosen from the permutation {1,2, ... ,n_i}, where n_i is the block-length of the i^{th} user's codeword, and wherein once this set of permutations are chosen, they are fixed and used in the apparatus over a

designated period of time, and wherein after this period of time elapses, another set of distinct random permutations are chosen for the next period and so on.